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Robert H. Kelley-Wickemeyer
Chief Engineer
Technology & Certification
Large Airplane Development

Boeing Commercial Airplane Group
P.O. Box 3707, MS 7X-TA
Seattle, WA 98124-2207

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John K.McGrath (AIR-100)
Aircraft Engineering Division Manager
Department of Transportation/FAA
800 Independence S.W.
Room 804
Washington DC 20591

BOEING

Dear Jack:

John Kennedy tells me that you and he were talking last week about the Safety Evaluation Guide that ICPTF Working Group III developed.

As John may have told you, I put together a summary of Working Group III's thought process we used to develop the Safety Evaluation Guide.

The enclosed document is that summary. John Kennedy, Web Heath and I have a meeting with Don Glasco on February 13 in Don's office to discuss the enclosure.

I hope you will find this useful in your attempt to understand the thinking behind the Safety Evaluation Guide.

Sincerely yours,

Bob Kelley-Wickemeyer

R. J. Kelley-Wickemeyer
Chief Engineer Technology & Certification
Large Airplane Development

cc 's (AIR-110)
Aerospace Engineer
Department of Transportation/FAA
800 Independence S.W.
Room 804
Washington DC 20591

RHK-W:dm

01/27/95

Guiding Principles

In the early meetings of the ICPTF Working Group III (WG III) we agreed on several fundamental guiding principles:

1. Commercial Air Transportation is very safe today.
2. We want to further improve that safety.
3. We do not want to improve air transport safety at an expense that will force the traveler to use a less safe means of transportation.
4. We want to first encourage safety improvements in areas that have more frequent and serious consequences.
5. We want to encourage effective actions that address safety hazards.

Approach

ICPTF Working Group III (WG III) consisted of representatives of regulatory agencies in the United States, Canada and Europe, foreign and domestic airlines, the Airline Pilots Association and airframe manufacturers from the United States, Canada and Europe. We recognized that it was not likely we would be able to develop a procedure that could be used by a "clerk" to automatically determine if a new action would provide an effective safety benefit. We did believe, however, we could provide some useful guidance to a team of experienced experts to supplement their good judgment.

In order to determine whether a safety change should be made, the following factors were considered to be important:

A. What has been the consequences of exposure to a given hazard? Or, what do we expect the consequences to be?
B. How often have those consequences happened? Or, how often do we expect them to happen?
C. How effective do we expect the action to be in dealing with the hazard?
D. What is the economic impact on society if the action is taken?

Items A) & B) – Consequences and Frequency

WG III addressed items A) and B) by determining the opposite extremes and then by addressing the expected variation between extremes. We often did sanity tests with examples to see if the [illegible]de sense.
The extremes of A) and B) were determined to be:

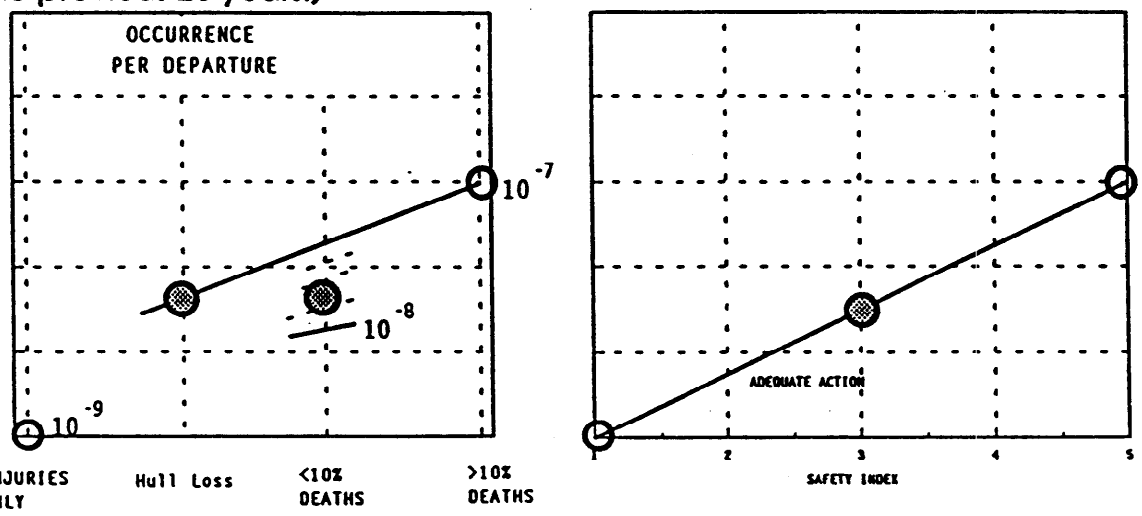
- a hazard that happened every year that caused everyone to die.
- a hazard that might happen in the life of the fleet that would result in injuries.

Two vertical lines were added to the left hand chart to represent those cases where there were *few* deaths and those cases where there were *hull losses with no deaths.* In order to place the lines on the chart, the group reached an agreement about the relative safety importance of different combinations of seriousness and frequency.

WG III finally decided that on the 1 to 5 scale described above, a *3* would equate to:

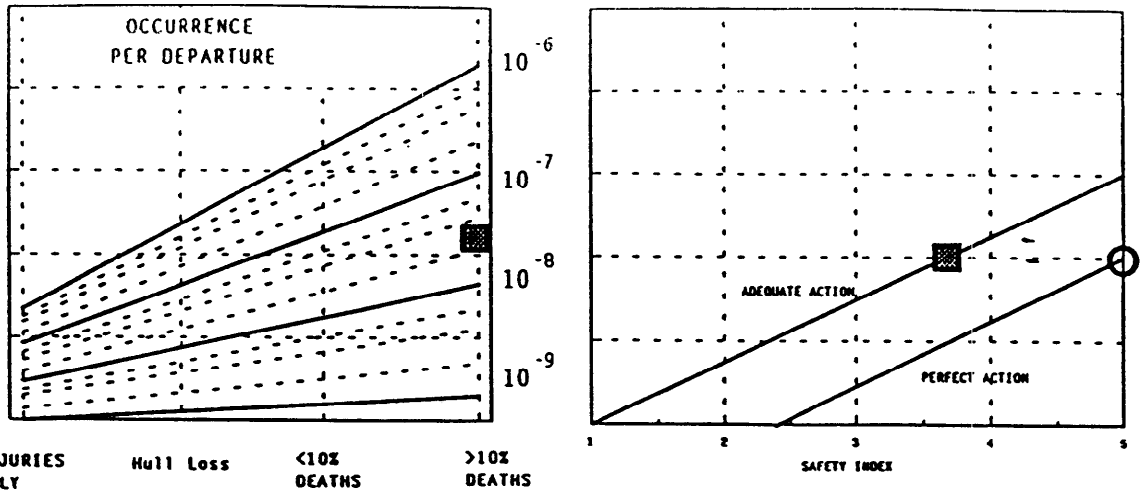
- an **adequate** action that addressed a *hazard that resulted in a hull loss once a year;* **or,**
- an **adequate** action that addressed a *hazard that resulted in deaths of less than 10% of the people onboard the aircraft every 5 years.*

That added the shaded points to the charts below. (When we made the chart in 1991, there had been about 10 million large commercial jet airliner departures in the last year; 40 million in the previous 5 years and 200 million in the previous 25 years.)



WG III also believed that if a Safety Index of 5 equated to an adequate response to one catastrophic hazard per year, then a Safety Index of **4** would equate to an adequate response to a hazard with a limited number of deaths every year.

Likewise, we believed if a Safety Index 3 equated to an adequate response to a hull loss each year, then a **2** would equate to an adequate response to a hull loss every 25 years. This added the following points to the chart and allowed us to draw the frequency lines on the left hand chart.



A line was then added to the right hand chart half way between the first two lines to represent the middle strategy of "eliminate, avoid, adequately deal with." WG III characterized this strategy as "Good". We defined it as:

> Action is fully effective in all probable or likely cases, but does not cover all situations or scenarios

The response to the wind shear hazard was an example of "Good" philosophy. There are wind shears in nature that are so strong no airplane can fly through them. Consequently, it is impossible to eliminate the wind shear hazard. The strategy was then to detect and **avoid** wind shears. However, if that strategy failed in a specific case, we devised an approach for **dealing with inadvertent** wind shear encounters. We prescribed pitching the airplane up to get maximum usable lift and then applying maximum controllable thrust.

However, not all proposed actions fit into the "eliminate, avoid, adequately deal with" strategy. A safety evaluation guide would have to address proposed actions that might have both safety benefits and safety disadvantages. These could be potential solutions that had not yet been perfected. An example of this might have been early Terminal Area Collision Avoidance Systems (TACAS). Before it was perfected, early TACAS control logic could command an airplane to pitch up past the point where the wing would stall. Furthermore, some early boxes became "confused" when they had to deal with a large number of potential threats. As a result, they had to be turned off in the terminal areas.

WG III believed the best way to motivate a team to identify and resolve these problems was to develop a class of proposed actions we labeled "poor." Those actions would work much of the time but they had significant negative side effects. WG III dealt with this by penalizing the Safety Index for a "poor action" relative to an "adequate action" by the same amount we rewarded a "perfect action." WG III characterized a "Poor" action as:

> Action is partly effective in some cases, but does not cover all probable or likely cases. Usually this action only addresses part of a hazard.

participant individually made a subjective evaluation of how effective each proposed action would be in addressing the identified hazard. The group then collectively evaluated each of the individual participant's answers for each proposed action.

The examples we tested were:

Rule	Hazard Addressed
25.963 amd't 69	Exploding engine, wheels or tires breaking a fuel tank access cover, leaking fuel & causing a fire
25.562 amd't 64	Trauma injury/death caused by seat collapse in those accidents where the airplane structure remains substantially intact
25.812 amd't 58	Inability of passengers to find exits in a cabin filled with smoke.
25.811 amd't 46	Passenger confusion in opening an exit door during an emergency, especially when there may be a crowd near the exit.
25.365 amd't 71	Cabin pressure venting into unpressurized compartments.
25.631 amd't 23	8 pound Bird strike on Empenage.
25.783 amd't 54	Inflight opening of external doors

This exercise proved very valuable. The discipline inherent in this method of evaluation made it very clear to WG III that the team of experts using this procedure had to be specific about the way the hazard was described. It was because of this exercise, the following instructions were added to the description of how to use the Safety Evaluation Guide.

> *"The effectiveness of an action is a direct function of the precision of the hazard statement in step B) and the intent statement in step C). The team using this tool for the first time would be well advised to repeat the exercise using a more specific definition of the hazard addressed and the consequences of the specific hazard."*

WG III also discovered that even with the diversity of backgrounds on the team, agreement was reached on the Safety Index to within 1 point with one exception. Surprisingly, the biggest difference in subjective judgments for the effectiveness of a proposed rule was with FAR 25.812 Amendment 58. This rule change called for floor proximity lighting of the emergency escape path. In retrospect, at the time the evaluation was made, WG III probably did not have enough human factors data available to make a good choice. The opinions ranged from "this was a great idea" to a belief passengers would get confused because of the lack of standardization between airplanes and airlines and because of the use of a red light to indicate this is where the passenger should go to exit the airplane. Neither view was so firmly held that it would not change based on more expert information.

We said "Resource Index" was composed of five basic elements -- labor, capital, material, operating costs and revenue loss. Those terms are defined below for the purpose of the evaluation guide. (These definitions may be different than some people associate with the terms "labor, capital, material, operating costs and revenue loss".)

- **Labor** is work carried out in the design, fabrication, inspection, operation or maintenance of an aircraft for the purpose of incorporating or demonstrating compliance with a proposed action. Non-recurring and recurring labor requirements, including training, will be considered.
- **Capital** is construction of new, modified or temporary facilities for design, production, tooling, training or maintenance.
- **Material** is costs associated with product materials, product components, inventory, kits and spares.
- **Operating Costs** are only associated with fuel, oil, fees and expendables (such as de-icing fluids).
- **Revenue Loss** includes departure delays, product downtime, earning capability or performance loss due to seats, range or airport restrictions.

WG III needed to associate Resource Index with the Safety Index. We also needed to define the intermediate values of the Resource Index. Since airplanes are safe today, we did not want to force the traveler into a less safe means of transportation. Therefore, we decided that it would not make sense to incorporate a change that only scored a Safety Index of 4 but had a Resource Index of 100. On the other hand, it might make sense to incorporate that change if it's Safety Index was 5 even though such action might cause companies to go out of business. We do not expect there are many (or any) actions left for the industry to take that will have a Safety Index of 5.

At the other extreme, it did not make sense to incorporate a change if the Safety Index was 1 even if the related Resource Index was as small as we could estimate. The smallest possible Resource Index is 5 (the summation of a score of 1 point for each of the 5 resource categories). Considering the types of hazards and actions that could result in a Safety Index of 2, it did make sense to incorporate those changes if the Resource Index was the lowest possible, 5.

...result was the addition of the lower chart to the charts used to deve...p the Safety Index.

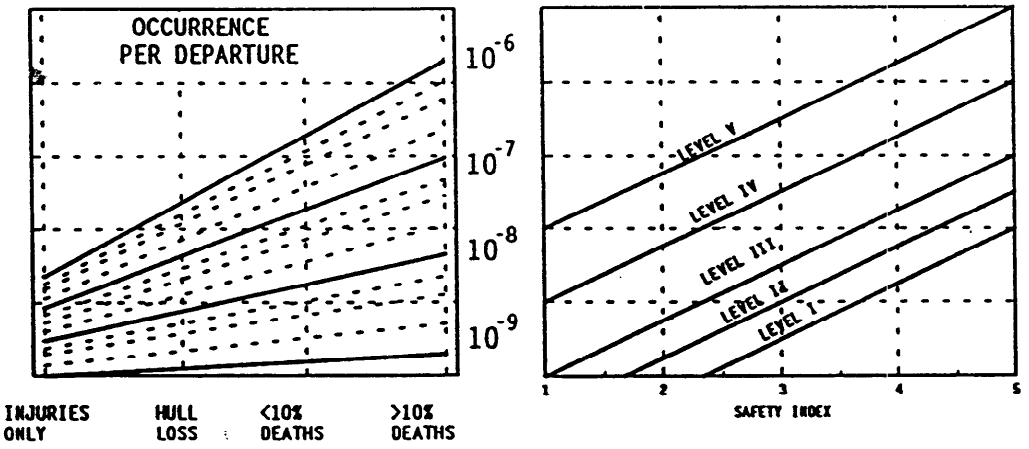
SAFETY / RESOURCE EVALUATION GUIDE

1. REGULATION OR ACTION:

2. HAZARD ADDRESSED:

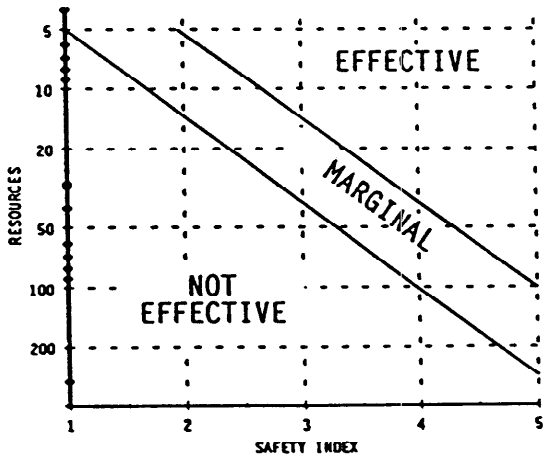
3. SPECIFIC INTENT OF ACTION:

☐ NEW PRODUCT DESIGN
☐ DERIVATIVE PRODUCT DESIGN
☐ NEWLY PRODUCED PRODUCT
☐ IN-SERVICE PRODUCT



	POINTS			
LABOR	1	4	20	100
CAPITAL	1	4	20	100
MATERIAL	1	4	20	100
OP. COST	1	4	20	100
REV. LOSS	1	4	20	100
TOTAL				

RESOURCE INDEX



Another Check of the Method

At this stage, we sanity tested the methodology again. We used the same hazards and the actions that had been used earlier. Notice we used a consensus Safety Index when comparing Resource Index to Safety Index. Each WG III member made an independent assessment of the resources that would need to be expended in each category. Each WG III member then

Rule	Effect of rule	Hazard Addressed	Occurrence Frequency per 200 million departures of large jets				Safety Index
			Injuries	Hull Loss	<10% Deaths	>10% Deaths	
25.963 amd't 69	Design fuel tank access covers to min. penetration by likely foreign object & be fire resistant	Exploding engine, wheels or tires breaking a cover, leaking fuel & causing a fire	1	0	0	1	3.4 2x3.1, 5x3.5, 1x3.8
25.562 amd't 64	Upgrade design standards for seats to account for dynamic loading and to provide for an impact injury criteria	Trauma injury/death caused by seat collapse in those accidents where the airplane structure remains substantially intact	1	0	3	2	3.5 3x3.1, 1x3.5, 4x3.8
25.812 amd't 58	Provide floor prox. emergency escape path visual guidance when all sources of cabin lighting >4' above the aisle floor are totally obscured by smoke. Effective on all Part 121 airplanes after 11/26/86.	Inability of passengers to find exists in a cabin filled with smoke.	0	0	3	5	3.7 2x4.6, 2x3.9, 1x3.5, 1x3.0, 1x2.6
25.811 amd't 46	1) Clarify existing rules to indicate how far to move the passenger door exit handles to release locking mechanisms, and 2) make the handles conspicuous in an emergency	Passenger confusion in opening an exit door during an emergency, especially when there may be a crowd near the exit.	0	0	0	1	3.0 3x2.7, 2x3.0, 3x3.4
25.365 amd't 71	Improve structural requirements for pressurized cabins and compartmen	Cabin pressure venting into unpressurized compartments.	1	0	1	2	3.6 5x3.4, 3x4.0
25.631 amd't 23	Design Empenage for continued safe flight and landing after 8# bird strike.	#8 Bird strike.	0	0	0	0	2.9 1x2.5, 2x2.6, 1x2.9, 4x3.2
25.783 amd't 54	Requires doors to be fully closed and locked prior to pressurization. Show by analysis inadvertent opening is extremely improbable	inflight opening of external doors	1	0	1	1	3.3 1x3.0, 2x3.2, 1x3.2, 2x3.5, 1x3.6

Note: 3x3.1 means three people evaluated this rule at 3.1

SAFETY EVALUATION GUIDE

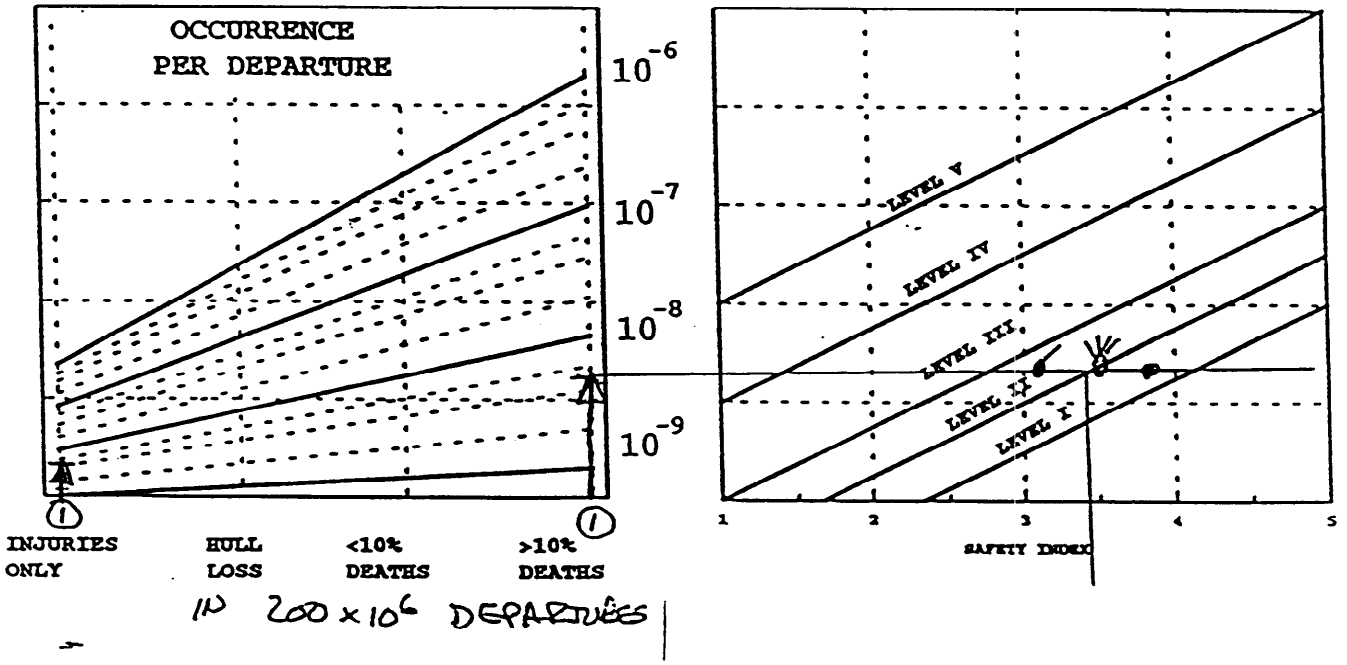
DATE: _____

1. SAFETY ITEM: 25.963 - A69

2. HAZARD ADDRESSED: EXPLODING ENGINE, WHEELS OR TIRES BREAKING A FUEL TANK COVER AND LEAKING FUEL WHICH MAY CATCH FIRE

3. EFFECT OF ACTION:

DESIGN FUEL TANK COVERS TO MINIMIZE PENETRATION BY LIKELY FOREIGN OBJECTS AND BE FIRE RESISTANT



IN 200×10^6 DEPARTURES

GROUP CONSENSUS - 3.4 SAFETY INDEX
3.1, 3.5, 3.5, 3.1, 3.8, 3.5, 3.5, 3.5

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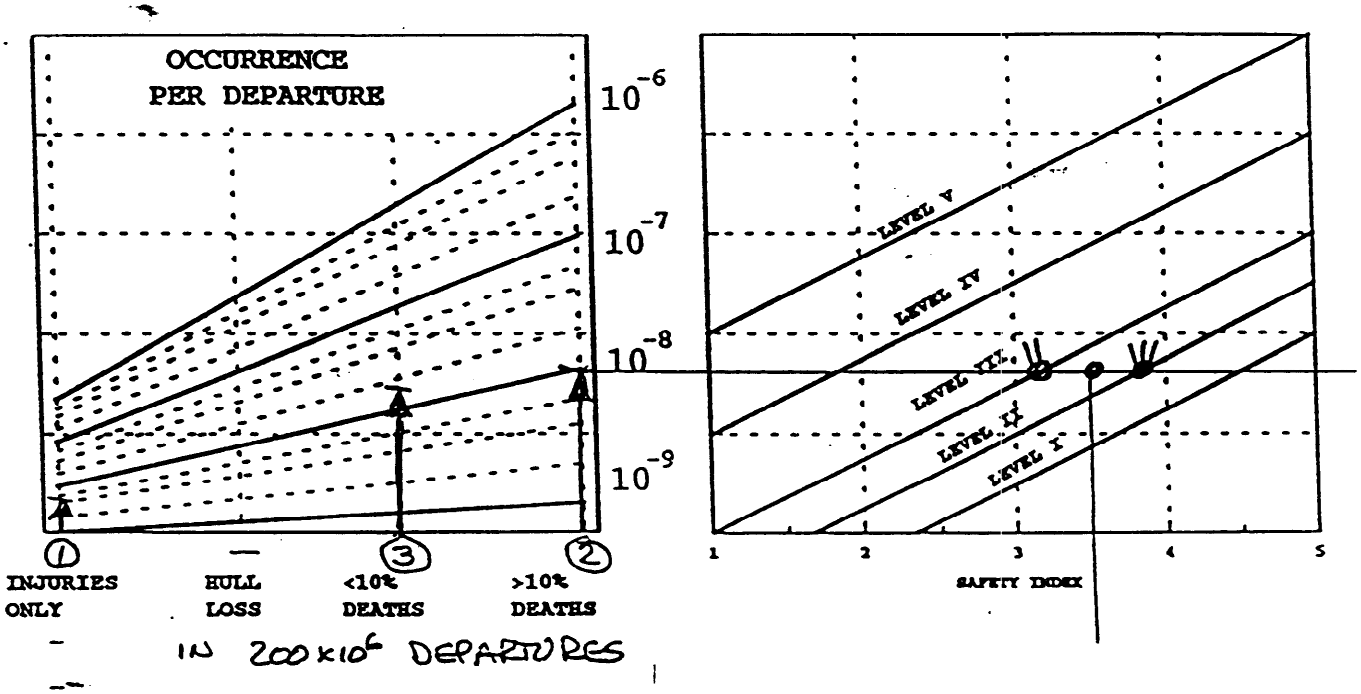
SAFETY EVALUATION GUIDE

DATE: _____

1. SAFETY ITEM: 25.562 - A64 16G SEATS

2. HAZARD ADDRESSED: TRAMA INJURY / DEATHS CAUSED BY SEAT COLLAPSE (INCLUDES HEAD IMPACT CRITERIA) WHEN STRUCTURE STILL SURVIVABLE

3. EFFECT OF ACTION: DESIGN SEATS FOR 16G'S DYNAMIC RATHER THAN 9G'S STATIC



GROUP CONSENSUS – 3.5 SAFETY INDEX
3.8, 3.1, 3.5, 3.1, 3.8, 3.8, 3.8, 3.1

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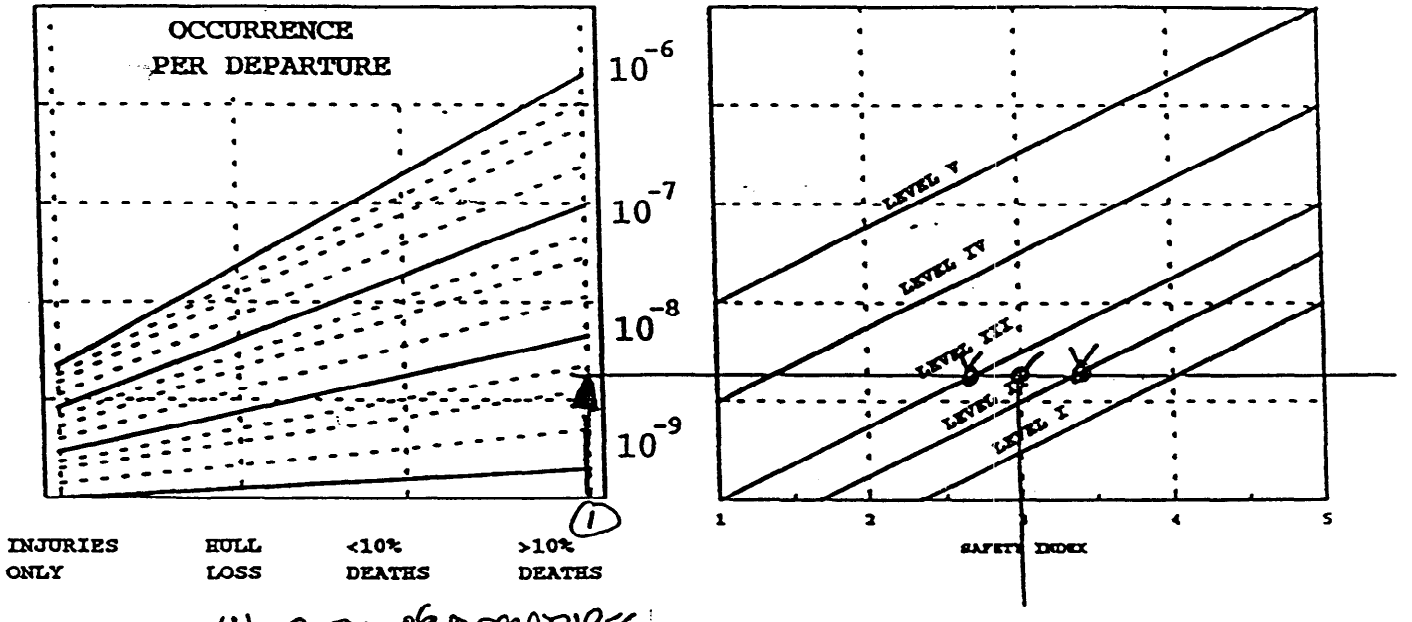
SAFETY EVALUATION GUIDE

DATE: _____

1. SAFETY ITEM: 25.811 – A46

2. HAZARD ADDRESSED: CONFUSION BY PASSENGERS IN OPENING DOORS DURING EMERGENCY EXIT

3. EFFECT OF ACTION: IMPROVED EMERGENCY EXIT MARKINGS



IN 200×10^6 DEPARTURES

GROUP CONSENSUS – 3.0 SAFETY INDEX
3.4, 3.4, 3.0, 2.7, 3.0, 3.4, 2.7, 2.7

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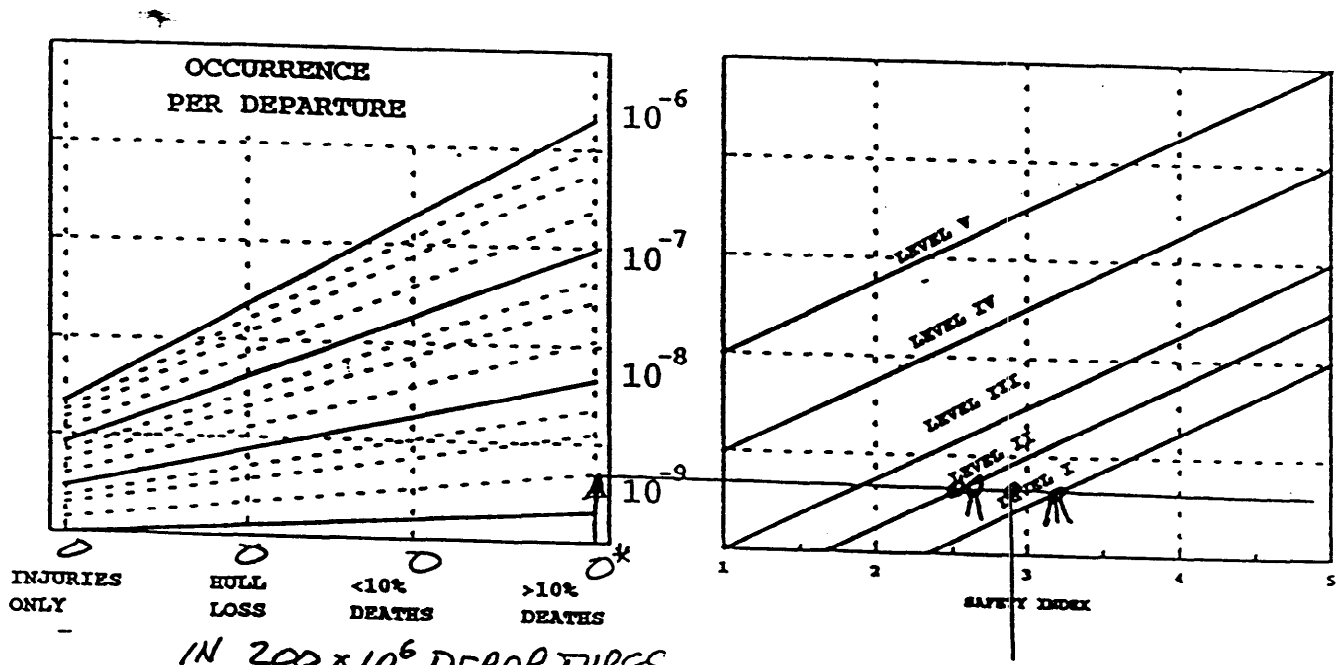
SAFETY EVALUATION GUIDE

DATE: _____

1. SAFETY ITEM: 25.631 - A23 BIRD STRIKE

2. HAZARD ADDRESSED: 8 POUND BIRD ON EMPENNAGE

3. EFFECT OF ACTION: DESIGN EMPENNAGE TO CONTINUE SAFE FLIGHT AND LANDING AFTER 8 POUND BIRD STRIKE



IN 200×10^6 DEPARTURES

* HAS NOT HAPPENED TO JET TRANSPORTS BUT DID HAPPEN TO A PROP. A/P NOT IN DATABASE

GROUP CONSENSUS - 2.9 SAFETY INDEX
3.2, 3.2, 3.2, 2.5, 3.2, 2.9, 2.6, 2.6

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